DEC 12 1925

East Engin.
Library

Volume II November, 1925 *Number II*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of the Motor Bus

(From a Cold Weather Point of View)

PUBLISHED MONTHLY BY
THE TEXAS COMPANY, U. S. A.
TEXACO PETROLEUM PRODUCTS

Some Common Causes of Motor Bus "Trouble"

A. Use of Gasoline of Too Low Volatility may require:

1. Excessive cranking,
2. Excessive choking,
3. Priming, and
4. Abnormal carburetor adjustment.

In turn Excessive Use of the Choke, and Priming may cause:

1. Black smoke,
2. Loss of power,
3. Overheating of the engine,
4. Excessive carbon formation,
5. Impaired piston seal and poor compression,
6. Reduction of the viscosity of the lubricating oil (by dilution) with consequent reduction in lubricating value,
7. Premature wear of all engine parts,
8. Scored cylinders and pistons.

Abnormal (and Possibly Improper) Carburetor Adjustment may cause:

1. Excessive fuel consumption,
2. Loss of power,
3. Uneven running of the engine,
4. Crankcase dilution,
5. Poor Acceleration.

B. Disregard of Engine Lubrication, and Infrequent Changing of Oil may result in:

1. Water accumulation, and freezing,
2. Accumulation of abrasive matter,
3. An inoperative oil pump,
4. Premature wear of cylinder walls, and other working parts,
5. Gumming,
6. Poor gasoline mileage.

Too High an Oil Level may cause:

1. Excessive oil consumption,
2. Fouled spark plugs,
3. Carbon deposits in cylinders,
4. And valve trouble.

Too Low an Oil Level may cause:

1. Inefficient lubrication,
2. Excessive wear of all engine parts,
3. Poor gasoline mileage,
4. Overheated engine,
5. Pounding,
6. Loss of power,
7. Seized pistons,
8. Scored and burned out bearings.

C. Disregard of Generator, or Motor Bearing Lubrication, may cause:

1. Burned out bearings,
2. Scoring,
3. Burnouts (if oil gets into windings),
4. Run down battery.

D. Use of Too Heavy a Lubricant in Differential and Transmission Gear Cases may cause:

1. Unnecessary consumption of power,
2. Difficulties in gear shifting,
3. Channeling of the lubricant, with
4. Consequent lack of lubrication,
5. Wear of upper bearings.

Too Light a Gear Lubricant may cause:

1. Excessive noise, and wear on gear teeth,
2. Possible leakage through gear case and axle bearings, to wheels and brakes, with
3. Consequent loss of brake efficiency.

E. Lack of Attention to Chassis Lubrication may cause:

1. Excessive wear of all parts,
2. Danger of accident because of failure of steering mechanism, etc.
3. Broken springs,
4. Squeaks,
5. Premature old age.

F. Use of Cooling Solution Which Is Liable to Freeze may cause:

1. Radiator leaks,
2. Cracked cylinder blocks,
3. Overheated engine,
4. Damage to the circulating system.

G. Neglect of Storage Battery or Allowing It to Become Discharged may cause:

1. Freezing of electrolyte,
2. Corrosion of terminals and mountings,
3. Permanent injury.

LUBRICATION

A Technical Publication Devoted to the Selection and Use of Lubricants

Published Monthly by

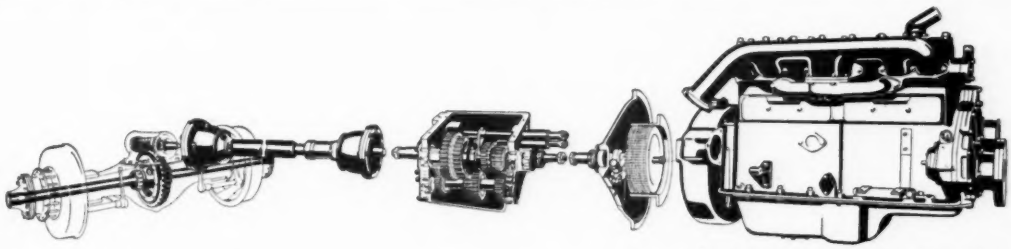
The Texas Company, 17 Battery Place, New York City

Copyright 1925, by The Texas Company

Vol. XI November, 1925 No. 11

Change of Address: In reporting change of address kindly give both old and new addresses.

"While the contents of LUBRICATION are copyrighted, other publications will be granted permission to reprint on request, provided article is quoted exactly and credit given to THE TEXAS COMPANY."



Courtesy of Continental Motors Corporation

Fig. 1—The five principal units on the power line of a gasoline driven motor bus, viz.: The motor, the clutch, the transmission, the propeller with universals, and the rear drive with differential. All require the most careful attention to lubrication if they are to function with unison and the least amount of friction.

Lubrication of the Motor Bus

(From a Cold Weather Point of View)

THE practicability of the Motor Bus as developed during the past two or three years of intensive operation has ushered in an era of trackless transportation of unbounded possibilities.

The age of the "jitney" has passed. Or, would it be better to say that the "jitney" has grown up; the palatial motor buses which frequent our highways, which keep to time table schedules with railroad punctuality, being the result of this transition.

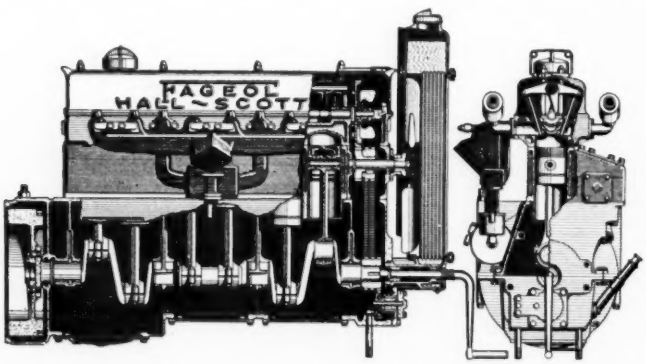
The natural sequence has been a marked development in the design and adaptation of the motor bus. Essentially this latter is a glorified automobile, with all the fine points of the modern high-priced limousine, and a few distinctive ones of its own to enhance its dependability and comfort. The possibilities are so vast that builders and automotive engineers today are sparing neither time nor expense in the perfection of their buses.

Quite naturally in view of this trend towards perfection in design and construction, like effort must be made to insure perfection in operation. Essentially this involves lubrication. For the most intricate mechanism is only as efficient as the lubrication of its working elements. The use of unsuitable lubricants, their faulty application, or their inability to meet working conditions may easily throw into the discard all of the efforts of the builders towards the perfection of their equipment.

The records of many prominent motor bus fleet owners are outstanding examples of the extent to which careful attention to lubrication will promote successful and continued operation. In fact it is no exaggeration to state that it is possible for a bus to run upwards of 100,000 miles between complete overhaul periods if properly lubricated. The practice of operators who attain such results is usually to drain their crankcases every night. This used oil can be quite readily purified and rendered suitable for re-usage in the engines; experience indicating that approximately 80 per cent can be recovered. So the matter of engine lubrication is not

extremely costly, in fact the cost of labor and make-up oil is but a fair rate to pay for the insurance of continued operation.

To emphasize the importance of this matter of lubrication, in cold weather especially, the motor bus is discussed in detail from this point of view. Those who are making enviable records in the operation of their buses will agree with our statements. Those who desire to emulate their example will do well to study the following carefully. Even the motor car owner can take a leaf from our advice to the bus operator.



Courtesy of Fageol Motors Co.

Fig. 2—Phantom view of a six-cylinder motor bus engine. All bearings are force feed lubricated through drilled crankshaft and hollow rocker arm shaft. Oil is forced under pressure to cam shaft and flows over chain drive to sump.

THE ENGINE

The modern motor bus engine is of either the sleeve or poppet valve type. In essential details it involves practically the same principles of operation as the automobile engine. It is, therefore, subject to much the same limitations and conditions in regard to lubrication. In brief it is of the four cycle type designed as a rule for full pressure lubrication throughout, or a combination of pressure lubricated bearings with spray or splash lubricated cylinders.

It is unnecessary to go into details relative to engine design, or the intricacies of lubricating systems. We all are motor car operators to a more or less extent, and intimately familiar with the functioning of the automotive engine. But the matter of lubrication, the selection of suitable engine oils, etc., and the factors which may influence their effective operation oftentimes occasion considerable confusion.

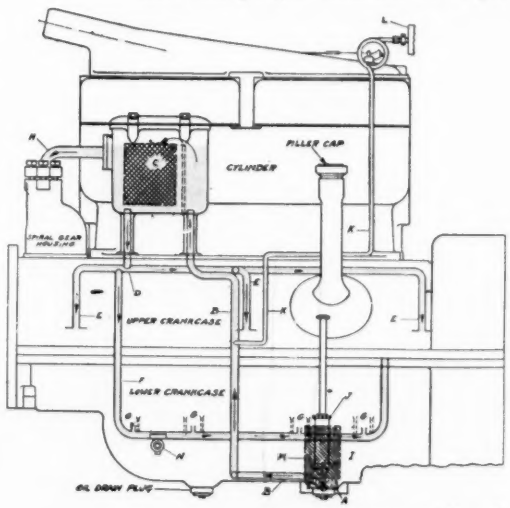
When we take into account the comparatively high investment involved in a motor bus, its scientific design, and the perfectness of its construction, we can readily appreciate the necessity for keeping it running effectively, and as economically as possible. Luxurious fittings and comfortable riding sell the motor bus to the general public—but only as long as it keeps running. Therefore, we all are interested in motor bus lubrication, from the owner to the most unimposing passenger, for lubrication is the secret of dependability.

CONDITIONS AFFECTING COLD WEATHER LUBRICATION

Inasmuch as the motor bus must function regardless of temperature or weather conditions, those factors which may influence the lubrication of its engine are of the utmost importance. We are, therefore, vitally interested in priming, choking, control of engine temperatures, water in the gasoline, carburetor adjustment, water in the lubricating oil, crankcase dilution, carbon formation, draining of the crankcase and selection of the engine oil. These points are discussed in considerable detail below.

Priming and Choking

Under extremely cold engine conditions, especially in starting, the amount of gasoline which will vaporize without external heat is considerably smaller than in warm weather or when the engine is hot. As carburetors are adjusted for the heated condition, in order to obtain the proper mixture of vapor and air it is customary to use the choke, which cuts down the amount of air delivered to the mixture on starting, or resort to "priming," i. e.,



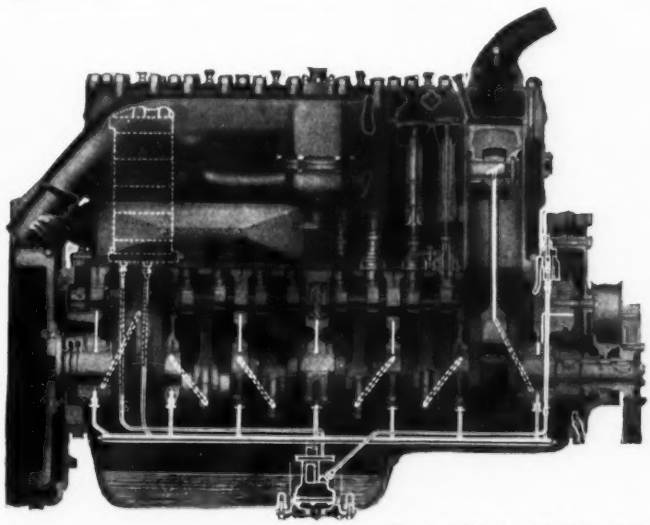
Courtesy of International Motor Co.

Fig. 3—A motor bus engine oil circulating diagram. Arrows indicate oil flow. A—Oil Circulating Pump—located in Crankcase Sump. B—Oil Pipe to Top Tank. C—Oil Tank and Filter Screen. D—Oil Distributing Pipe for Main Bearings. E—Oil Branch Pipes to Main Bearings. F—Oil Distributing Pipe to Troughs. G—Oil Troughs for Crankpin Lubrication and Splash. H—Oil Overflow Pipe Lubricating Timing Gears. I—Oil Reservoir—Lower Crankcase. J—Oil Level Indicator. K—Oil Pipe to Pressure Indicating Gage on Dash. L—Oil Pressure Indicating Gage on Dash. M—Oil Pump Filter Screen. N—Emergency Oil Level Cock.

the addition of an excessive amount of gasoline to the cylinders through the pet cocks.

Both priming and choking must be carefully carried out. Especially in the use of the choke will there be the possibility of considerable dilution occurring. If used excessively for any length of time naturally a comparatively uniform flow of very rich mixture will take place.

The use of more volatile gasoline, of course, would obviate this condition to a certain extent. The fact must not be overlooked, however, that dilution will occur with any motor fuel even where so called high test aviation gasolines are used. **The higher the volatility, however, the less will be the necessity for using the choke in cold weather operation.**



Courtesy of Continental Motors Corp.

Fig. 4—Detailed view of a motor bus engine. White lines indicate the oil travel. Note pressure pump in the bottom of the crankcase, the oil filter and ample capacity of the case.

During the process of warming up it is well to adjust the spark and throttle levers as nearly as possible to a point where the engine will run evenly and fire on all cylinders. Where buses are equipped with a primer, in very cold weather the priming charge should be shot into the manifold while turning the engine over with the starter. This will insure getting the charge into the compression chamber.

Control of Engine Temperatures

To counteract these effects as far as possible and maintain more nearly the required engine temperatures, suitable radiator covers or shutters are employed by many motor bus operators.

These devices should not simply be installed and closed or opened carelessly. They require intelligent adjustment if they are to bring about the desired results. In this connection the advice of the International Motor Co. relative to Mack buses will be of decided interest, viz.:

"The shutters should be kept closed until the motometer temperature reaches between 'warm' and 'hot,' which is between 160 and 180 degrees F.

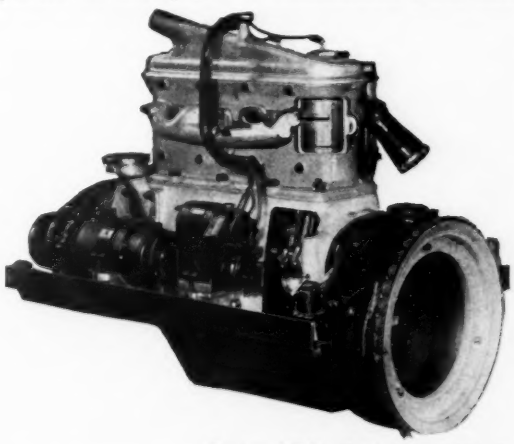
"This temperature should be maintained by the driver under variations of load, grade and weather conditions by adjustment of the shutter opening.

"Whenever the engine is stopped it is well to close the shutters in order to conserve the heat in the cooling system to make starting easy."

Water in the Gasoline

In cold weather operation, water in the gasoline should be carefully guarded against, due to the possibility of its giving trouble by freezing in the gasoline pipe, carburetor, or even the bottom of the storage tank. Should a drop of water come in contact with a fine mesh strainer located in the fuel line it may entirely cover the mesh with a film. In turn, should this film freeze, which might happen even when immersed in the fuel, a stoppage in the flow of gasoline would occur, perhaps even to the extent of shutting off the entire supply.

To locate the source of such trouble while out on the road might be a difficult matter, as the frozen film covering the screen may not be readily apparent to the eye, and considerable labor and time would no doubt be involved before the cause of the stoppage in the fuel line could be ascertained. Even if such a film of water did



Courtesy of Yellow Truck & Coach Mfg. Co.

Fig. 5—Cut-away view of a sleeve valve motor bus engine showing cooling and lubricating features of sleeves and pistons, and bearing details.

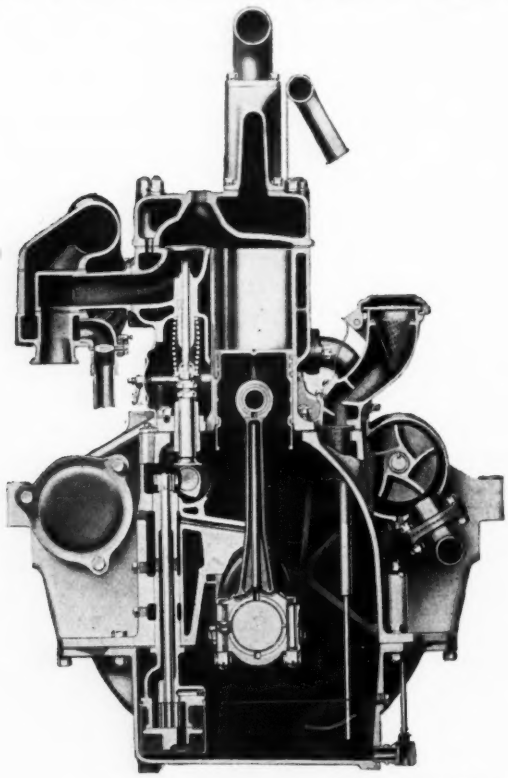
not freeze there would still be the possible objectionable feature of misfiring.

In the motor bus storage tank, water could gain easy access were the filling cap left loose, the tank, filled in the rain, or certain of the seams leaking. Another prevalent cause of water accumulation in the gasoline tank is condensation of the moisture in the air. This is especially liable to occur if the bus is stored in a warm garage, and then driven out under excessively cold atmospheric temperatures. In the same manner a certain amount of water will be condensed in the crankcase.

Water in the carburetor is indicated by misfiring. In this event the carburetor drain should be opened to remove any slugs of water that may be present. It would also be advisable for the driver to thoroughly inspect his tank for the presence of water at the earliest opportunity, and to drain the gasoline from the system and strain it where necessary.

Carburetor Adjustment

In connection with winter operation of the motor bus, carburetor adjustment plays a most important part. In fact, it is one of the most essential adjustments on the engine, and there is a marked difference between winter and summer settings. While the effort should always be made to run with as lean a mixture as possible, in cold weather the normal richness of the gas must be markedly increased. Were this not done, starting difficulties would be great and it would be necessary to use the choke almost continually, with the detrimental results noted above. Hence the modern carburetor is built for suitable adjustment in order to vary the percentage of gas and air, as well as the temperature of the latter, that go to make up the fuel mixture. Such adjustment should always be made by an expert. If the average driver attempts it, in all probability he will run into all sorts of difficulties.



Courtesy of The Buda Co.

Fig. 6—Front end view of a six-cylinder bus engine, showing the interior in detail. Note oil pump, strainers and oil leads.

Improper adjustment of a carburetor may give rise to:

1. An excessive consumption of fuel,
2. Loss of power, and
3. A decidedly uneven running of the engine.

Water in the Lubricating Oil

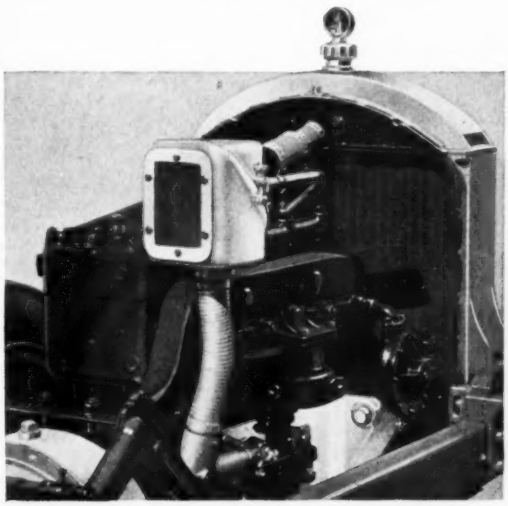
Water accumulation in the crankcase, and the possibility of freezing and injury to the oil pump when the engine stands idle without external heating, also requires consideration. Some of this water is accounted for by the condensation of the steam (or water vapor) that is one of the products of combustion when the gaseous mixture of gasoline vapor and air is fired.

Under normal weather conditions, with a sufficiently warm engine this vapor will be emitted along with the other exhaust gases. In cold weather, however, particularly on starting or warming up a cold engine, or in event of the cooling water temperature being too low, part or all of this steam will be condensed through contact with the cold cylinder surfaces. The resultant water will tend to leak past the piston rings and drain down into the crankcase to settle in a layer below the oil and usually surrounding the oil pump; in some cases this water will also become mixed with the oil. If this accumulation becomes extensive, and if the bus is stored or left standing for any length of time in an atmospheric temperature much below 32 degrees F. (freezing) in all probability the engine base will cool sufficiently to enable this water to freeze. This would render the oil pump filter screen inoperative or cause the pump to break, thus preventing oil circulation, which would result in burned-out bearings and seized pistons.

In addition expansion and contraction which will accompany such freezing—and the subsequent melting, may also possibly cause a fracture in the crankcase bottom, which will involve considerable expense for welding or replacement.

Crankcase Dilution

In the average running of an automotive engine, crankcase dilution, or the reduction of the viscosity of the lubricating oil by unburned fuel, occurs at practically all times. It may be especially rapid in cold weather. Normally, however, it will go only so far, apparently reaching an equilibrium point after a sufficient length of time, notwithstanding the entry of a certain amount of the lighter diluents whenever the choke is used or priming resorted to.



Courtesy of International Motor Co.

Fig. 7—View of a motor bus engine showing the air filter which is so essential in keeping dust out of a motor bus engine, and the vaporizer which keeps liquid gasoline out of the cylinders.

On the other hand, if dilution for any reason, as by excessive use of the choke, becomes abnormal and the diluent is by far the major part of the lubricating mixture, a condition may arise, as for instance in the sudden application of the load, wherein the lighter or diluent portions will be rapidly evaporated from the film on the cylinder walls because of rapid heating of the cylinders. In such a case, the lubricating film may be reduced sufficiently in thickness so that scored cylinders will be a possibility.

Experiments have shown that while the state of equilibrium between the lubricating oil and the lighter fuel portions will vary with the nature of the constituents, it will balance itself of its own accord if sufficient time is allowed. That is, if an equilibrium condition of 20 per cent diluent was normal for the case in question, if 40 per cent diluent were started with in the crankcase, the lubricating mixture would tend to return to its state of equilibrium.

Effects on Bearings

The usual amount of reduction in viscosity due to dilution, in the average engine today may, of course, tend to promote the pumping of oil by journals in their rotation, inasmuch as lighter fluids will lend themselves to more ready handling, if it can be called such, but only under lower speeds. The higher the rubbing speeds the lower will be the pumping efficiency of the bearing. Furthermore, increase in the rubbing speed between a journal and bearing causes an increase in frictional heat.

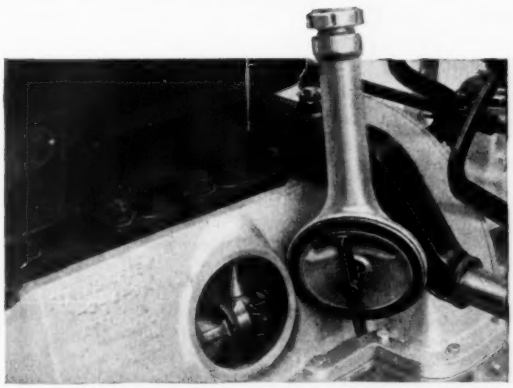
As a result a diluted engine oil, under higher speeds and normal operating temperatures must possess very high lubricating ability and be as free as possible from carbon or other foreign matter if it is to furnish a suitable film to protect the bearings. **Only can this be obtained by the most careful refinement, and the rendering of the original oil as pure as possible.**

Unless the oil is given every attention in its refinement there will be considerable possibility of it being broken down in service especially where the frictional heat developed in the bearing is not being adequately carried away by the oil itself. The ideal in automotive bearing construction is to plan for practically the entire removal of frictional heat by the oil, thereby preventing this heat from reaching either the bearing surface or journal. But this ideal is not practicably obtainable. Therefore the oil must be of such a character as to—

1. Be capable of maintaining the requisite lubricating film.

2. Resist the breaking down effects of heat.

3. And develop as little hard carbon as possible if subjected to continued service under overheated conditions.



Courtesy of International Motor Co.

Fig. 8—View of a bus engine crankcase breather. This serves also as a filling spout. It can be readily removed without tools for inspection of the crankcase and bearings.

Carbon in an engine combustion chamber, on valves, piston heads, on spark plugs or in ring grooves, etc., is a detriment from the viewpoint of ultimate power developed. In bearing clearance spaces, however, it may in addition

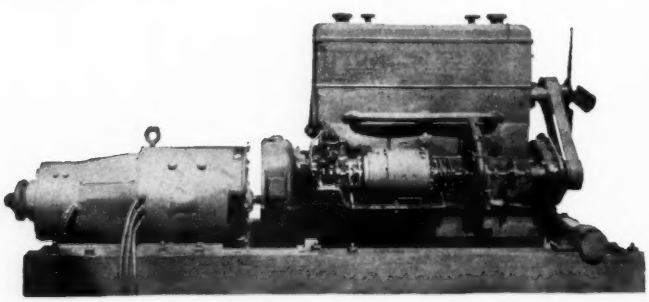
result in mechanical failures due to an impairment of circulation of the lubricant by the clogging of grooves or oil ducts. It must, therefore, be guarded against with the utmost care.

Carbon Formation

In connection with this matter of dilution, it is decidedly necessary to keep in mind the relation which it bears to excessive carbon formation, or the building up of so-called carbon deposits, not only on spark plugs, pistons, cylinder heads, around the rings, and on the valves and seats, but also in the crankcase or oil sump itself.

While carbon formation is more generally attributed to incomplete combustion of the fuel, to the use of excess lubricating oil or to the entry of silicious foreign matter such as, road dust via the air intake or breather pipe, we must not lose sight of the fact that dilution is also a pertinent contributor. In other words, it is perfectly evident that the lighter the lubricant or the thinner the film on the cylinder walls, the more readily will it splash or succumb to the wiping effects of the piston. This will, of course, increase the possibility of pumping or forcing of the lubricating film up into the combustion chamber where it will be ultimately burned. The direct result is the development of more or less carbon therein.

The intensity of this latter will, of course, depend upon the residual carbon content of the oil. Where the latter burns cleanly the amount of such deposits will be relatively small. **Furthermore, if the oil is properly refined and adapted to the purpose, such carbonaceous matter will be soft in appearance, low in quantity and comparatively easy of removal.**



Courtesy of General Electric Co.

Fig. 9—A typical electric driven motor bus power plant showing an automotive generator, direct-connected to a gasoline engine.

Over extended periods of operation, however, carbon deposits, whatever their nature, will be bound to increase. Furthermore, where pumping or forcing of a certain amount of lubricating oil into the combustion chamber occurs, the ultimate oil consumption will be higher, with a reduction in the mileage developed per gallon. In addition, dilution may involve the possibility of a certain amount of loss of compression due to impairment of the piston seal when the viscosity of the oil is so reduced that the lubricating film is comparatively readily wiped off by the piston rings.

So it is important to operate an engine at all times with a view to reducing the occurrence of crankcase dilution as much as possible. To bring this about and promote the efficiency of operation, and extend the life of the engine bearings and cylinders, certain precautions must be observed. In brief, they are:

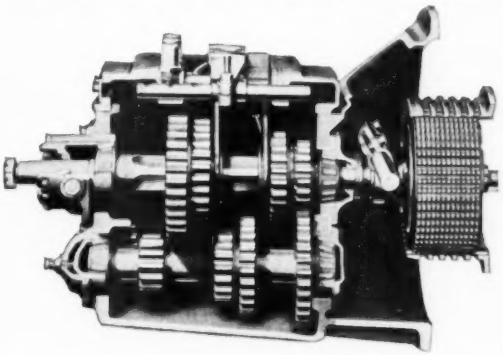
1. Run on as lean a mixture as possible in conformation with atmospheric temperature and the load to be handled.
2. Do not flood the carburetor.
3. Prime as little as possible.
4. In cold weather be sure that the hot air intake pipe attachment is in proper position to enable the admission of heated air to the carburetor.
5. Keep the engine warm, especially in cold weather.
6. When necessary to use the choke, let the sound of the engine be the guide. As soon as one or two revolutions are made and the engine indicates steady running, push the choke back in or turn the handle to "hot" position according to the make of the bus.
7. Never flush the crankcase with kerosene alone except where arrangement of the oiling system permits complete drainage of the case. Always give it a final slushing with light motor oil. Kerosene is helpful in removing heavier particles of adhesive sludge. On the other hand kerosene also removes the lubricating oil film.
8. Change the oil at frequent intervals. The cost of oil is negligible in comparison with the cost of lay-up and repairs on the average bus.

Draining the Crankcase

To most effectively minimize water accumulation in the crankcase, as well as dilution of lubricating oil in cold weather, the oil should be changed and the case drained at regular and periodic intervals. Water accumulation and dilution cannot be entirely eliminated, but frequent change to fresh oil will certainly minimize the possible detrimental effects.

It is usually good practice to wash the

crankcase with a quart or two of warm, light motor oil after draining, to remove sediment deposits from corners and other crevices. The use of kerosene as an engine wash has been practically discontinued, due to the possibility of part of the kerosene remaining in the crankcase to dilute the fresh motor oil. Frequently the crankcase drain plugs are not located so that all the washing oil can be readily and completely drained, and for this reason it is generally advisable to use a light lubricating oil for flushing, even though the expense may be slightly greater.



Courtesy of Fageol Motors Co.

Fig. 10—Detail view of a motor bus transmission and disc clutch assembly. Note tapered roller bearings on gear shafts, and the provisions for rendering case oil tight.

Never run the engine by its own power in such cases, but turn it by hand or with the self-starter. Then drain off the wash oil. After draining, the engine can be given its usual charge of fresh oil. It will be always advisable to drain the crankcase of used oil while the engine is hot, inasmuch as considerable of the sediment and other accumulations of foreign matter will be drained out, and it may not then be necessary to bother with a light oil wash each time.

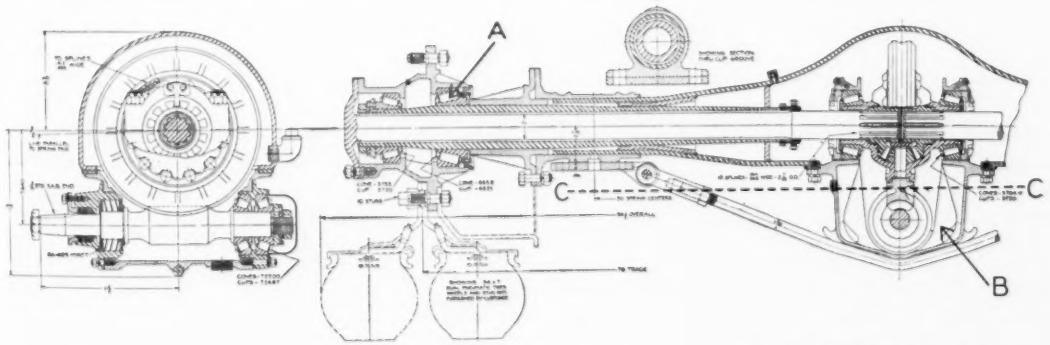
In event of breaking in a new engine, or one wherein the cylinders have been rebored, it will be generally advisable to drain and flush the crankcase more frequently for the first few days of operation, refilling the crankcase each time with clean motor oil in the usual manner.

There is a very good practical reason for these first changes of oil and cleaning of the crankcase. In relatively every new engine, or instance of rebored cylinders, there will be present a certain amount of the metallic surfaces which will have a tendency to wear or polish off in the form of minute particles and mix with the lubricating oil during the period over which the pistons and cylinders are worked into a smooth "running fit."

It is perfectly evident that these particles will act as abrasives to cause rapid and abnormal wear of the engine bearings, cylinders, piston rings and other parts served by the lubricating oil, unless they are removed from the system. Naturally, the only effective way to remove them is to thoroughly drain and wash out the crankcase after the engine has operated a sufficient length of time to insure that practically all of such free metal has been taken up by the lubricating oil.

Crankcase draining is a matter of economics. The above discussion is primarily for the benefit of those who are more or less unfamiliar with its bearing on overall efficiency. The essential question is: whether it is more economical to drain every 200 or 2000 miles, for example, and get an operating range of 50,000 or 100,000 miles between general overhaul periods. Experience, the practicability of purifying such oils, labor conditions, and the cost involved must be the deciding factors.

In other words, where one fleet owner will find it best to drain every night, as already mentioned, with a possible operating period of 100,000 miles, another may consider it most



Courtesy of The Timken-Detroit Axle Co.

Fig. 11—Sectional view of an underslung worm drive rear axle showing details of construction and provisions for preventing leakage of lubricant. "A"—indicates wheel bearings which require a heavy roller bearing grease of high melting point; "B"—is the gear housing wherein a straight mineral low pour test gear lubricant should be used; and "C-C"—indicate the proper level of this latter.

economical to run from 2000 to 5000 miles on a charge of oil, even though he may find it necessary to overhaul after a much shorter operating period.

Selection of Motor Oils

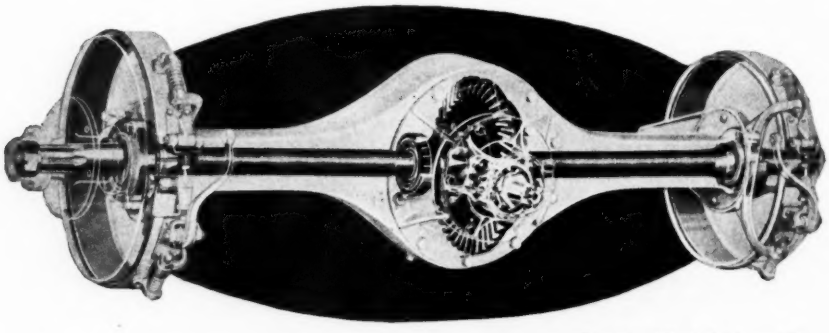
In cold weather operation of the motor bus, the efficiency of the engine from a lubricating viewpoint will be largely dependent upon the operating temperature, and viscosity of the motor oil used. In turn the viscosity is essentially a function of the temperature. Hence it is evident that under colder atmospheric conditions the viscosity of a lubricant will increase, resulting in a lower degree of fluidity and involving greater internal fluid friction.

Naturally, this will cause a reduction in lubricating efficiency and necessitate a greater consumption of power to bring and maintain the bus at the desired speeds. If the normal viscosity of the oil at 100 deg. F. be relatively high it is perfectly clear that under exticular engine, the use of a medium viscosity oil in the winter would generally be proper.

It can be appreciated that too viscous a lubricant might give rise to difficulty in starting, or be the cause of all manner of engine troubles such as burned bearings, scored cylinders or seizing of certain parts, due to its being too viscous to be properly transmitted to these parts.

In other words, any inability of the pump to lift this abnormally heavy oil, or any possibility of it being discharged back into the crankcase through the relief valve, may result in the engine operating for perhaps several minutes with practically no lubrication.

The claim may be advanced that the more or less common condition of crankcase dilution will soon cause the thinning down of such a lubricant to enable it to flow properly. Crankcase dilution, however, is an extensive variable, and it should never be depended upon to perform any such function. In fact even with proper use of the priming cup and choke it



Courtesy of Clark Equipment Co.

Fig. 12—Phantom view of a bevel drive rear axle showing relation of gears, the tapered roller bearings and brake design and construction.

ceedingly low temperatures this oil might become so sluggish as to be relatively difficult to pump. It is for this reason that lighter, lower viscosity motor oils are used in the winter than in the summer. Another reason is that a heavier lubricant congeals far more rapidly when subjected to cold, than a lighter oil. In the refining of motor oils, it is possible to vary the pour test or temperature of congealment to some extent. Naturally, the lower this temperature, or in other words, **the lower the pour test the more suitable and dependable will the oil be for cold weather operation,** other factors being equal. In view of this, the bus operator should endeavor to obtain as low a pour test oil as possible for winter usage.

In general winter operation, the viscosity of the motor oil should be reduced so as to give approximately the same lubricating efficiency as in warm weather. For example, were a heavy oil recommended for summer service in a par-

would be a very doubtful agent to rely upon for viscosity reduction, and much damage could be done before dilution to the extent required would take place while operating with a lubricant of too high a viscosity.

If, in the opinion of the operator, the atmospheric temperature is so low as to render an otherwise suitable motor oil temporarily so sluggish as to be incapable of proper lubrication, he should insure lubrication by warming up his cold engine very slowly, until the heat generated has reduced the viscosity of the oil sufficiently to enable it to be properly pumped.

ELECTRICAL EQUIPMENT

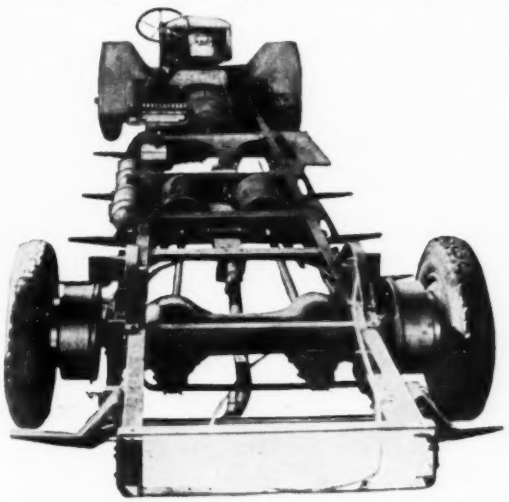
In addition to the gasoline engine, a motor bus of the electric drive will also carry a generator, suitable electric motors for driving the rear axle, and also the necessary controlling equipment. The power delivered to the motors is controlled by means of a standard accelerator acting on the throttle.

With the engine "wide open" it is impossible to impose an overload, due to the fact that the generator is designed to develop a definite maximum horse-power commensurate with the maximum power rating of the engine.

The engine and generator are directly connected by means of their respective crank and armature shafts, usually through flexible couplings, the generator being in line with, and directly behind, the engine.

By direct connecting the generator to the engine via a flexible coupling, the shocks which would otherwise be set up by the piston on the crankshaft when connected to the heavy armature of the generator are minimized.

In the gas-electric bus, there may be one or two driving motors involved, according to the design, the desire for freedom in aisle space, and the duty to be performed. In regard to the advantages of the single versus the double motor installation, it is interesting to note the remarks of Henry S. Baldwin, of the Automotive Engineering Department, General Electric Company, as advanced in a recent paper presented before the Society of Automotive Engineers,* i. e.:



Courtesy of General Electric Co.

Fig. 13—Rear view of chassis of an electric drive motor bus showing engine, generators and motors. This is a two-motor drive, by means of two worm-driven differentials as seen on the rear axle.

"Each, undoubtedly, has its good features. The single motor is lighter for a given chassis, is mounted more easily in the frame, can be employed with the standard rear-axle and differential, and involves less expense than the double-motor equipment. These seemingly important advantages are offset, in the opinion of many engineers and operating men, by the advantages of the double-motor drive in reducing the diameter of the driving motors, in allowing a lower platform and in the ability of the two-motor drive with the motors in parallel to move the driving wheels somewhat as if a locked differential were used.

"Motorbuses, particularly in city traffic, must run close to the curb to accommodate passengers; and at such times it has been found that the inner and outer driving wheels do not always have the same road conditions, so that one may be held and the other may spin without moving the motorbus. This difficulty does not occur with the double-motor drive. It has also been found that the double-motor drive reduces the skidding effect under slippery conditions; and this in itself is an important factor in the safe transportation of passengers in thickly congested traffic."

Courtesy of The Six-Wheel Co.

Fig. 14—View of the rear axles and differential of a six-wheel motor bus, with the rear wheels in tandem.

Regardless of whether one or two motors are involved, they will be hung or suspended just forward of the rear axles, being connected to the latter through a differential worm or gear drive.

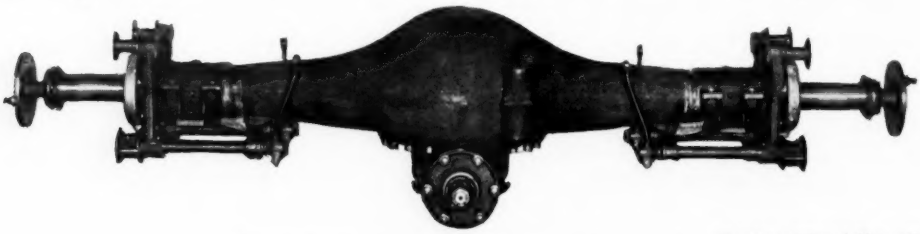
Lubrication

Generator and motor lubrication is essentially a matter of the lubrication of ball-bearings, such devices being at present most extensively used for the carrying of the armature or rotor shafts. This matter of ball-bearing lubrication as pertaining to electric motors in particular, was extensively discussed in the October 1925 issue of "LUBRICATION." Attention is therefore called to that article, from a general interest point of view.

As a rule, generator and driving motor bearings in the modern gas-electric bus will require grease lubrication. Conditions differ from those involved in industrial motor bearing lubrication. Loads are comparatively heavier, as for example, when a bus must pull through bad roads, up hills, or through snow, and motor

* Journal of the S. A. E., July, 1925.

speeds are considerably higher. Therefore, the amount of heat involved may frequently be very much greater; in consequence there will be more chance of lubricating failures. Where these latter involve the breakage of the balls, etc., the parts will tend to lock the driving shaft in fixed position. Where this occurs on the road it may be necessary to dismantle the rear end before the bus can be towed into the shop.



Courtesy of Fageol Motors Co.

Fig. 15—Exterior view of the housing of a worm drive rear axle.

We must realize also that there is but limited space for any reserve lubricant. Therefore, this latter must be of the highest quality, and adequately capable of resisting the breaking down effects of heat. The most suitable product is a grease compounded with an extremely heavy, straight mineral oil. The adhesive characteristics of such a product insure a relatively permanent film of lubricant on the surfaces of the balls and raceways.

The starting motor, on the other hand, can be readily lubricated with oil. The bearings are usually oil-tight and dust-proof, with ample provision in the form of baffles, ribs, oil throwers, etc., against the occurrence of windage and the passage of oil spray to the windings. In consequence, it is perfectly practicable, and usually customary to use the same oil as employed in the gasoline engine. There are generally no problems involved in cold weather operation of starting motor bearings, if an oil of proper viscosity and low pour test is used.

THE TRANSMISSION AND DIFFERENTIAL OR REAR END DRIVE

Transmission and differential construction in the average bus is much similar to the modern automobile. In the gas-electric bus the transmission is done away with; in fact this is claimed to be one of the advantages of such a bus, over the direct drive type of vehicle.

The necessity of transmission gears in the latter type of bus, of course, requires their consideration, especially from a cold weather lubricating point of view. Essentially such an installation involves a suitable train of gears to enable operation of the bus at variable speeds commensurate with the speed of the engine. They are of the selective type. In other words, the operator is able to use such gear ratios or speed reductions by the mere shifting of a lever, as may be necessary on account of traffic conditions, the roadway, etc.

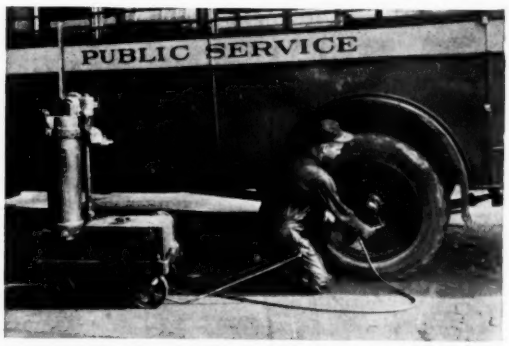
The differential or rear axle drive in turn, likewise involves an arrangement of gears. The differential is common to both types of buses. Essentially these may involve worm or bevel gears according to the design of the drive. The object of the differential is a dual one, viz:

(a) To transmit power from the engine, and electrical equipment where involved, to the rear axle; and

(b) To enable the rear wheels to rotate at different speeds, as is necessary when the bus is turning corners or operating in any other than a straight line.

Both worm, and spur and bevel gear drives are used in the bus industry today. Each is rugged, simple of design, relatively silent and capable of effectively meeting the usual heavy duty involved.

Whatever the type of drive, by virtue of its construction, the transmission and rear end of the motor bus in general involve two distinct lubricating conditions. In a word, the lubrication of the gears, and worm where the rear end is worm driven, and the accessory shaft bearings.



Courtesy of Carr Fastener Co.

Fig. 16—Lubricating the rear wheel axle bearings of a motor bus by pressure by means of a high pressure grease lubricator.

Inasmuch as the one lubricant must, as a rule, serve both gears and bearings it must be of sufficient viscosity to not only maintain the requisite film of lubricant on the gear teeth but also have adequate penetrative ability to serve the bearings whatever their type or design. Such a lubricant should always have as low a pour test as possible where it is to be used under low temperature conditions. Many so-called compounded gear lubricants while admirably suited to warm weather conditions, are totally inadequate when temperatures drop below 40 or 50 degrees F. As a rule they "set" or congeal to such an extent that the worm or gears will frequently cut a channel in the main body of the lubricant, thereby preventing it being carried to the teeth of the element above or distributed to the bearings.

Courtesy of The Bassick Mfg. Co.

Fig. 17—View of a high pressure grease lubricator in which the motive power is compressed air.

In consequence, straight mineral lubricants will be best adapted to the gears of the average bus. In winter a viscosity of approximately 115 seconds Saybolt at 210 degrees F. should be used. In warmer weather a viscosity of 200 seconds will be best. If refined from crudes of suitable base, especially to meet low temperature conditions, it is perfectly practicable to obtain such lubricants of as low a pour test as 15 to 20 degrees F.

In certain cases of both transmission and differential lubrication, however, it may be found best to thin down such lubricants to approximately the correct viscosity for cold weather service, by the addition of a low pour test motor oil. Especially is this advantageous where temperatures are below the pour test of the lighter product mentioned above. In such instances, reduction of viscosity by means of a motor oil of approximately zero pour test will oftentimes solve an impending problem very satisfactory. The amount of motor oil necessary will depend of course upon the severity of the weather and the possible temperatures that may be encountered.

In general the addition of sufficient motor oil in an approximate ratio of two parts of gear lubricant to one part of oil will render the resultant lubricant in the gear case of the proper consistency. When this lubricant is thoroughly mixed or blended in the transmission and rear axle (which occurs automatically when the gears rotate) there will normally be sufficient flow in cold weather to insure lubrication of all gears and bearings, and it will have the added advantage of reducing the power necessary for starting.

THE CHASSIS AND OTHER PARTS

In a consideration of such other parts of the motor bus as require lubrication we will have to deal with the universal, the front and rear wheel bearings, the steady bearings, which carry the propeller shaft, the water circulating pump, the steering mechanism, spring shackle bolts, air springs, door engines where employed, the magneto bearings, and the air compressor.

Pressures on chassis parts are more or less identical with those involved in heavy duty industrial machinery. Therefore the lubricants used must give a thick film. In other words, the greases selected must be manufactured from extremely heavy oils.

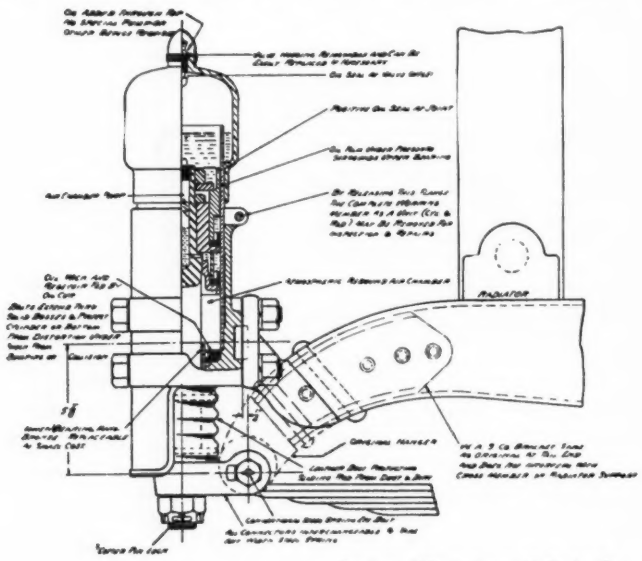
The Universal Joint

Among such parts the universal joint involves one of the several lubricating problems due to the rotational speed at which it operates. The resultant centrifugal force tends to throw off the lubricant from the cross pin bearings, perhaps to involve loss or waste of the former, or at least the possibility of insufficient lubrication. On starting, there is also the possibility of development of abnormal pressure; this may cause light greases to be forced out through the sealing cap or grease retainer. For this reason the utmost care must be observed in selecting a lubricant of sufficient body and adhesive characteristics to resist this action, as far as possible. A soap thickened residual petroleum product has been found to meet this requirement most effectively.

Axle Bearings

A similar product is adaptable for the lubrication of both front and rear axle bearings. In the case of the latter, especially, and also the

former where four-wheel brakes are involved, it is necessary for the lubricant to effectively resist the thinning down effects of heat, which so frequently result when braking is necessary to any extent. Such a lubricant, by virtue of the high viscosity of its mineral oil constituent meets this requirement admirably.



Courtesy of Westinghouse Air Spring Co.

Fig. 18—Details of an oil-sealed air spring as used in motor bus service. Captions indicate the essential features of construction, the oil wick and reservoir, the means of sealing, and installation.

Furthermore, in cold weather, it has an admirable characteristic, in that it does not solidify or congeal at low temperatures, and is therefore capable of performing its intended function, even though it may probably become somewhat more inert. As a general rule, filling of the hub caps will insure an adequate supply for several hundred miles of operation, although certain bus builders recommend filling daily at the time of general daily chassis lubrication.

Other Parts Requiring Grease Lubrication

Elsewhere on the bus chassis, as for example on propeller shaft steady bearings, steering and brake mechanisms, spring shackle bolts, etc., grease lubrication is in general provided for by the builders. This is usually of the pressure type, some form of hand or automatic grease gun being employed to charge the necessary amount of lubricant to the respective parts.

Cold weather presents no serious problems in regard to the lubrication of such parts, provided the grease used has a sufficiently low "set" point to insure that it will not become so stiff as to involve an abnormal amount of internal friction or fail to give the necessary amount of lubrication.

CONCLUSION

In brief we have attempted to present a discussion of motor bus lubrication essentially as applied to cold weather operation. Sufficient explanatory matter is included, which, together with the illustrations, will serve not only to enlighten the layman as to the relationship of the bus to his automobile, but also to perhaps interest the bus operator. For none of us are intimately familiar with all types of equipment, as lack of time precludes an intensive study in most cases.

If, therefore, our presentation proves of interest, if the illustrations serve to enlighten, and if our arguments relative to the importance of care and attention to lubrication in cold weather are heeded, the object of this article will have been attained. For cold weather does involve a problem, requiring an intimate knowledge of the factors which may serve to impair lubrication as in the case of the engine; and an insight into the essential characteristics of the lubricants which will most effectively surmount these difficulties whatever the parts to be lubricated.

Printed in U. S. A. by
EDGAR C. RUWE CO., INC.
47 West Street, N. Y. C.